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PB-271 452

Lake Whatcom
Whatcom County, Washington

National Eutrophication Survey, Las Vegas, Nev

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

Jul 77

PB 271 482

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

PB-271 482

Report
on
Lake Whatcom
Whatcom County
Washington
EPA Region X
Working Paper No. 875

With the cooperation of the
Washington Department of Ecology
and the
Washington National Guard
July, 1977

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2. PB-277 482
4. TITLE AND SUBTITLE: Report on Lake Whatcom, Whatcom County, Washington	5. REPORT DATE: Prepared July 1977
7. AUTHOR(S): Anonymous (National Eutrophication Survey Staff)	8. PERFORMING ORGANIZATION REPORT NO.: Working Paper No. 875
9. PERFORMING ORGANIZATION NAME AND ADDRESS: National Eutrophication Survey U.S. Environmental Protection Agency P.O. Box 15027 Las Vegas, NV 89114	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS: Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460	13. TYPE OF REPORT AND PERIOD COVERED: Final - 1975 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES: Prepared in cooperation with the U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Eutrophication Survey Branch, Corvallis, OR 97330

16. ABSTRACT:

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		08H 08C

18. DISTRIBUTION STATEMENT: Release unlimited	19. SECURITY CLASS (This Report)	21. NO. OF PAGES: 43
	20. SECURITY CLASS (This page)	22. PRICE: PC A03, MF A01

EPA Form 2220-1 (9-73)

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REPORT ON LAKE WHATCOM

WHATCOM COUNTY, WASHINGTON

EPA REGION X

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 875

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

July 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

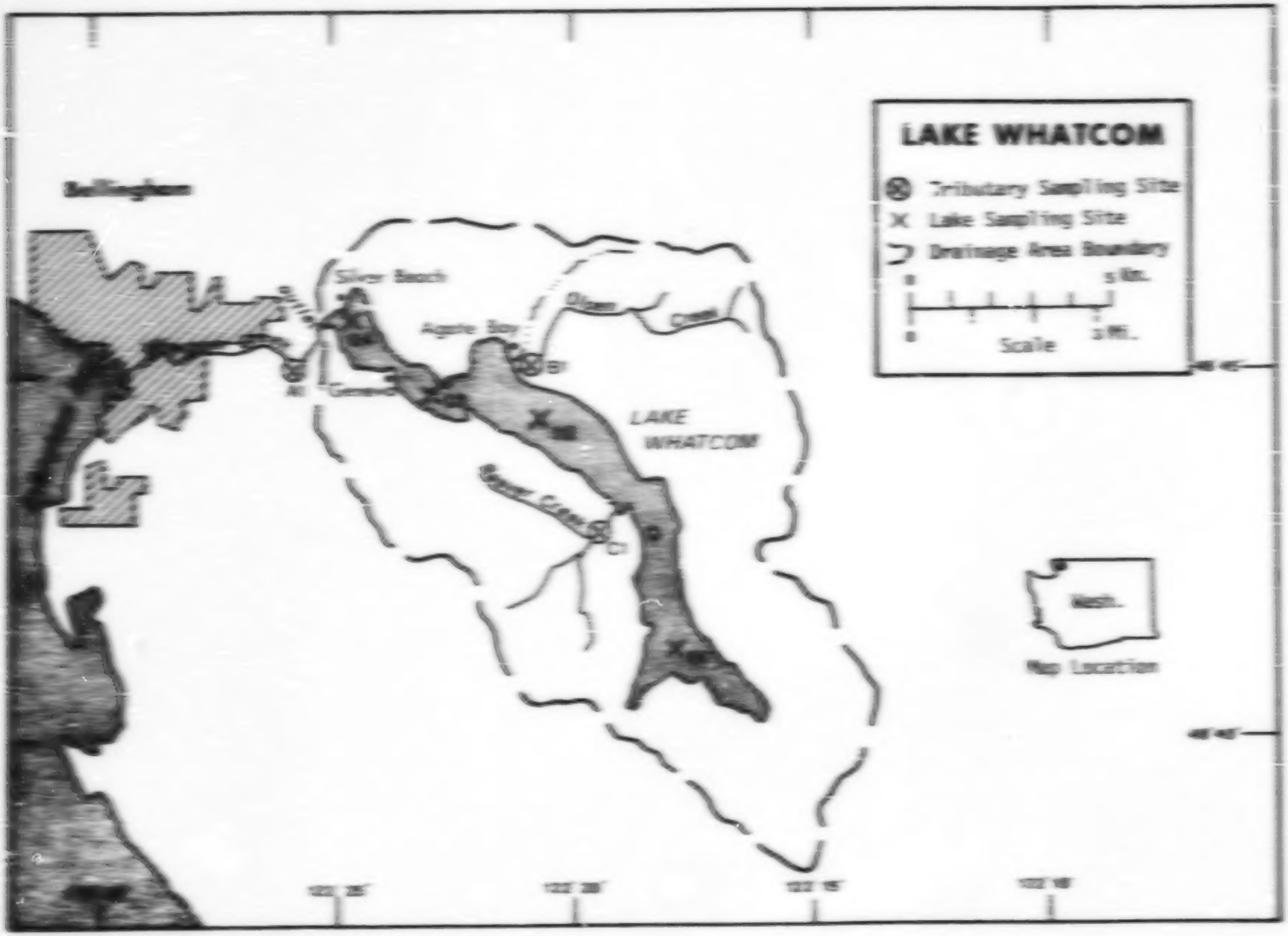
The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Washington Department of Ecology for professional involvement, to the Washington National Guard for conducting the tributary sampling phase of the Survey, and to those Washington wastewater treatment plant operators who provided effluent samples and flow data.

Ms. Barbara Olau, Lake Restoration Program, and the staff of the Washington Department of Ecology, Lake Restoration Program, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

Major General Howard S. McGee, Adjutant General of Washington, and Project Officer Colonel Clinton C. Johnson, who directed the volunteer efforts of the Washington National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES
STATE OF WASHINGTON

LAKE NAME	COUNTY
American Lake	Pierce
Banks Lake	Grant, Douglas
Chelan Lake	Chelan
Diamond Lake	Pend Oreille
Green Lake	King
Keechelus Lake	Kittitas
Mayfield Lake	Lewis
Medical Lake	Spokane
Moses Lake	Grant
Ozette Lake	Clallam
Sammamish Lake	King
Lake Whatcom	Whatcom
Lower Granite Reservoir	Garfield, Whatcom


LAKE WHATCOM
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Scale
Bellingham
Silver Beach
Agate Bay
Olsen Creek
LAKE WHATCOM
Smith Creek
Wash.
Map Location

REPORT ON LAKE WHATCOM, WASHINGTON
STORET NO. 5312

I. CONCLUSIONS

A. Trophic Condition:*

Based upon Survey data Lake Whatcom is considered early mesotrophic. Chlorophyll a values in the lake ranged from 2.5 µg/l to 5.0 µg/l, with a mean of 3.4 µg/l. Secchi disc visibility remained high in the lake throughout the sampling year, and potential for primary production as measured by algal assay control yields was moderately low. Of the 13 Washington lakes sampled in 1975, 10 had greater median total phosphorus levels, none had greater median inorganic nitrogen values and 6 had greater median orthophosphorus levels than Lake Whatcom.

Survey limnologists did not observe any problem algal blooms or macrophyte growths in the lake during the sampling year. However, other studies (Ketelle and Uttormark, 1971; Kraft and Mason, 1970) indicate there is a tendency towards eutrophication in the western end of the lake as a result of septic tank seepage from lakeshore residences.

*See Appendix E.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Whatcom was primarily limited by phosphorus during both spring and fall sampling rounds. The lake data suggest phosphorus limitation on all three sampling occasions.

C. Nutrient Controllability:

1. Point sources -

There were no known municipal or industrial point sources contributing to Lake Whatcom during the sampling year. There are two known fish hatcheries located on the lake (Lake Whatcom Fish Hatchery, and a state trout hatchery on Brannian Creek); however, annual nutrient contributions from these sources are not known.

The present calculated annual phosphorus loading of 0.13 g $P/m^2/yr$ is less than Vollenweider's (1975) proposed oligotrophic level for a lake with such volume and hydraulic retention time. Additional study is needed to determine the actual number and significance of septic tanks contributing to the lake nutrient budget, however, since it appears there are localized water quality problems in Lake Whatcom due to septic tank discharges. Ketelle and Uttormark (1971) report that there has been some sewering of lakeshore residences in an effort to control localized enrichment problems, but

it is not known at this time to what extent the sewering has been accomplished.

8. Nonpoint sources -

Nonpoint sources provided the entire phosphorus load to Lake Whatcom during the sampling year. Olsen Creek contributed 6.6% of the total phosphorus load, Beaver Creek contributed 14.3%, and ungaged drainage areas were estimated to have contributed 62.5% of the total.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were provided by E.E. Wolcott (1965). Tributary flow data were provided by the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 20.25 km^2.
2. Mean depth: 1.8 meters.
3. Maximum depth: 97.8 meters.
4. Volume: 37,005 x 10^6 m^3.
5. Mean hydraulic retention time: 95 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area (km^2)	Mean flow (m^3/sec)
B-1 Olsen Creek	9.8	0.30
C-1 Beaver Creek	20.0	0.58
Minor tributaries and immediate drainage	95.2	3.89
Totals	125.0	4.77
2. Outlet - A-1 Whatcom Creek	145.3	4.50

C. Precipitation:

1. Year of sampling: 100.6 cm.
2. Mean annual: 84.7 cm.

III. LAKE WATER QUALITY SUMMARY

Lake Whatcom was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake (Station 03 was only sampled once and Station 04 was sampled twice) and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first visit, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 67.0 meters at Station 01, 62.8 meters at Station 02, 17.1 meters at Station 03, and 16.3 meters at Station 04. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/31/75	1. Melosira	735
	2. Asterionella	331
	3. Chroomonas	257
	4. Stephanodiscus	184
	5. Tabellaria	110
	Other genera	[illegible]
	total	1,617
07/18/75	1. Tabellaria	773
	2. Synedra	193
	3. Cyclotella	38
	4. Mallomonas	38
	Other genera	[illegible]
	total	1,002
10/29/75	1. Asterionella	184
	2. Fragilaria	184
	3. Spondylosium	184
	4. Chroomonas	147
	5. Aphanocapsa	73
	Other genera	109
	total	881

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/31/75	01	3.8
	02	3.6
	03	6.0
	04	---
07/10/75	01	2.8
	02	2.9
	03	---
	04	2.6
10/29/75	01	2.5
	02	3.4
	03	---
	04	4.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 03/31/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.008	0.294	0.4
0.05 P	0.058	0.294	2.6
0.05 P + 1.0 N	0.058	1.294	26.5
1.00 N	0.008	1.294	0.3

b. 10/29/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.005	0.160	0.3
0.05 P	0.055	0.160	6.7
0.05 P + 1.0 N	0.055	1.160	29.9
1.00 N	0.005	1.160	0.4

8. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that potential for primary productivity as measured by algal assay control yield was moderate during both spring and fall sampling of Lake Whatcom. In both assays, there was a significant increase in yield over that of the control when phosphorus was added, indicating primary limitation by phosphorus. In both assays, the addition of nitrogen alone did not result in an increase in yield over that of the control, and the simultaneous addition of both nutrients resulted in maximum increase in yield.

The mean inorganic nitrogen to orthophosphorus ratios (N/P) in the lake data were approximately 36/1, 19/1 and 58/1 during spring, summer and fall visits to the lake, indicating phosphorus limitation (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Washington National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of March when two samples were collected. Sampling was begun in September 1974, and was completed in August 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Washington District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in kg/km^2/year, in Olsen Creek at Station B-1 and multiplying the means by the ZZ area in km^2.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
B-1 Olsen Creek	170	6.6
C-1 Beaver Creek	370	14.3
b. Minor tributaries and immediate drainage (nonpoint load) -	1,620	62.5
c. Known municipal STP's - None		
d. Septic tanks* -	75	2.9
e. Known industrial - None		
f. Direct precipitation** -	355	13.7
Totals	2,590	100.0
2. Output - A-1 Whatcom Creek	1,480	
3. Net annual P accumulation -	1,110	

*Estimate based on 250 lakeshore residences and 1 park.
**Estimated (See NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
B-1 Olsen Creek	10,895	6.5
C-1 Beaver Creek	25,410	15.2
b. Minor tributaries and immediate drainage (nonpoint load) -	106,435	63.5
c. Known municipal STP's - None		
d. Septic tanks* -	2,785	1.7
e. Known industrial - None		
f. Direct precipitation** -	21,860	13.1
Totals	167,385	100.0
2. Output - A-1 Whatcom Creek	89,670	
3. Net annual N accumulation -	77,765	

*Estimate based on 255 lakeshore residences and 1 park.
**Estimated (See NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Olsen Creek	17	1118
Beaver Creek	16	1970

E. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading (g/m²/yr)
Estimated loading from Lake Whatcom	0.13
Vollenweider's "eutrophic" loading	0.52
Vollenweider's "oligotrophic" loading	0.26

V. LITERATURE REVIEWED

Ketelle, Martha J. and Paul O. Uttormark. 1971. Problem Lakes in the United States. U.S. Environmental Protection Agency Project #16010EHR, University of Wisconsin, Madison, Wisconsin.

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U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R.A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

APPENDIX C

PHYSICAL AND CHEMICAL DATA

[illegible]

[illegible]

[illegible]

[redacted]

[redacted]

[redacted]

APPENDIX C

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1975

STATE OF WASHINGTON

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Washington lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in ug/l. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SDD- MEAN SEC	MEAN CHLORA	25- MEAN DO	[illegible] SUMM SUMMER P
5301	AMERICAN LAKE	0.027	0.195	343.000	4.822	15.000	0.067
5302	[illegible] LAKE	0.021	0.049	364.533	7.373	10.000	0.077
5303	CARLSON LAKE	0.005	0.070	333.000	0.405	6.441	0.027
5304	DIAMOND LAKE	0.014	0.013	303.667	14.537	14.250	0.033
5305	GREEN LAKE	0.027	0.050	425.000	2.003	15.400	0.009
5306	KEECHELUS LAKE	0.007	0.040	390.250	2.440	9.250	0.057
5307	MAYFIELD LAKE	0.014	0.100	482.000	4.250	10.400	0.007
5308	MOSSYROCK LAKE	0.075	0.205	491.714	10.425	15.000	0.146
5309	MOSES LAKE	0.115	0.250	463.600	25.060	14.600	0.050
5310	OLYMPIC LAKE	0.010	0.110	485.333	1.225	7.250	0.070
5311	SAMMAMISH LAKE	0.025	0.210	374.000	7.240	13.000	0.250
5312	WHATCOM LAKE	0.009	0.329	399.000	3.422	10.000	0.000
5313	LOWER YAKIMA RIVERMOUTH	0.033	0.150	495.500	4.875	7.250	0.070

| | | |